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ABSTRACT

This study was designed to determine the effectiveness of using computer-delivery for specific learning-strategy training with undergraduate students. Two learning-strategy tutorials were developed to introduce 60 students enrolled in introductory computing courses at Old Dominion University in southwestern Virginia to microcomputer components. Both tutorials covered the same content, but one addressed comprehension-directed strategies and the other memory-directed strategies. Students in the two treatment groups and a control group completed two delayed and separately administered tests, one requiring cued recall and the other recognition. Results of analyses of the data indicate that the group mean scores for the treatment groups were significantly higher than the control group mean scores on the cued-recall test; however, the mean scores of the two treatment groups were not significantly different on this test. The group mean scores of subjects receiving comprehension-directed strategy training were significantly higher than the scores for the memory-directed group on the recognition test, and the scores of both experimental groups were significantly higher than those of the control group. It is suggested that the memory-directed strategies will enhance learning in cases where memorization of basic vocabulary is required, whereas comprehension-directed strategies will enhance rule-learning and problem-solving. (27 references) (BBM)

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The Effects of Computer-Assisted Learning-Strategy Training on the Achievement of Learning Objectives

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The effects of computer-assisted learning-strategy training on the achievement of learning objectives

Introduction

Teaching individuals learning strategies is, in effect, teaching someone how to learn. If learning is a knowledge domain in the same way as any subject, for example chemistry or history, then successful learners have organized knowledge about learning processes in the same way that chemists or historians have organized knowledge for their domains (E. Gagne, 1985). There is a real possibility of improving and enhancing learning abilities through special programs of training, education, and other types of intervention (Carroll, 1989). This study examined the effects of computer-assisted learning-strategy training on learning from a computer-based tutorial about microcomputer components.

Previous Research

Snowman (1986) describes learning tactics as specific techniques used to successfully complete a learning task while strategies are general plans decided upon before engaging in a learning activity. He discriminates among kinds of tactics by their objectives which may be memory-directed or comprehension-directed. Memory-directed tactics include the use of mnemonics, outlining, underlining, and summarizing. He refers to questioning as a "comprehension-directed tactic geared more toward understanding the meaning of ideas and their inter-relationships than toward ensuring reliable recall of those ideas" (p. 256).

Generating Questions

Levin (1982) discriminated between the types of generated questions and their effect on types of test questions. Duell (1978) found that college students who generated knowledge and application level questions scored significantly better than students who did not generate questions and that learners generated low-level knowledge questions which were not effective for high-level tests. Andre and Anderson (1979) found that learner-generated questions were more effective than re-reading. They also found that answering teacher-generated questions were equally effective. Singer and Donlan (1982) found that students who were trained benefitted more from student-generated questions than those generated by the teacher.

Training students to generate questions has been an issue in many studies, but researchers observed mixed results from variables such as length and intensity of training, presence or absence of metacognitive

components, and varied knowledge levels (Andre & Anderson, 1978-1979; Dreher & Gambrell, 1982; Singer & Donlan, 1982; Frase & Schwartz, 1975).

Simpson (1986) investigated the use of writing as an independent learning strategy and developed PORPE (Predict, Organize, Rehearse, Practice, Evaluate). This strategy was designed to prepare students for success with essay exams. The "Predict" phase of PORPE asked students to generate potential essay questions after reading. Predicted essay questions were directed at higher levels of knowledge. Students were instructed to use verbs such as explain, criticize, compare and contrast. Simpson (1986) found that the strategy required time to master but was effective.
Anthony and Raphael (1987) examined the effects of questioning strategies and found that when subjects generated low-level questions, the strategy was ineffective. Thus, it is apparent that students must be taught how to generate effective questions directed towards the level of learning to be tested.

Purpose of study

Many educational psychologists agree that students need to learn strategies (Kulik, Kulik, & Schwab, 1983). However, the results of training programs vary as much as the training formats and delivery systems (Armbruster, 1987; Cook & Mayer, 1988; Holley & Dansereau, 1984). A systematic evaluation of strategy-training CAI would contribute to the field of study and provide prototypical software. Since microcomputers provide a learning environment that favors individualization, self-pacing, practice, and immediate feedback (Hannafin & Peck, 1988), it is reasonable to consider computer-delivered learning-strategy training. The goal of this study was to determine the effectiveness of specific strategy training on learning about microcomputer components with CAI assessed by specific levels of test objectives.

Information Processing and Memory-directed Strategies

Mayer proposed four components of the encoding process: selection, acquisition, construction, and integration (Mayer, 1988; Mayer & Greeno, 1972; Weinstein & Mayer, 1986). During selection, the learner attends to information received by the sensory register. Acquisition provides for active transfer of information from working memory to long-term memory. During construction, the learner connects ideas and develops an outline organization or schema (Bransford, 1979) or, while reading, forms a macrostructure (Kintsch and van Dijk, 1978). Finally, integration of newly acquired

information with information already held in long-term memory is necessary for learning transfer. To be effective, memory-directed learning-strategy training must address these mental processes.

Levels of Learning and Comprehension-directed Strategies

Intellectual skills can be categorized by complexity from skills requiring discrimination, conceptualizations, applying rules, and finally, problem solving (Gagne', Briggs, and Wager, 1988). Teaching learners about these levels of complexity and applying that information to generating questions can, in and of itself, be used as a form of learning-strategy training. By generating questions about information, such as microcomputer components, learners should understand the content well enough to apply rules and solve problems. Delivering that training by microcomputer-based tutorials should facilitate learning because of the characteristics of CAI.

Method

Subjects

Subjects consisted of 60 undergraduate students enrolled in introductory computing courses at Old Dominion University in southeastern Virginia. The mean age of all students was 28 years and ranged from 19 to 43 years. The subjects included only those students whose prior experience with computers consisted of very little word processing, playing games, or using computerized cash registers. As a result of a survey administered to 80 students, those students who reported taking prior computing classes were excluded from the study. In this balanced design, subjects were randomly assigned to one of three treatment groups consisting of comprehension-directed strategy tutorials, memory-directed strategy tutorials, or a control group. As computing students, subjects received 5 participation points towards their final grade.

Instructional and Assessment Materials

A tutorial was developed in order to introduce the learner to microcomputer components. The tutorial was created using Linkway, an authoring system. The learner had the option of selecting topics by clicking the mouse on the approriate space located on a graphic representation of a microcomputer. Learners accessed the tutorial in a Novell LAN microcomputer laboratory. The tutorial covered topics included under the headings: central processing unit, memory, secondary storage, input

and output devices, and peripherals. Wherever possible, graphic representations of components supported verbal descriptions and conceptualizations.

Two learning strategy tutorials, developed through the use of Linkway, addressed comprehension-directed strategies or memory-directed strategies. Both tutorials addressed the same content, microcomputer components, and were created within the same format. The same colors, navigational buttons, and fonts were used for each screen and both tutorials possessed the same number of screens or Linkway Pages. Both tutorials concluded with the same practice quiz about microcomputer components. Each tutorial began with the same Linkway Folder, analogous to a Hypercard Stack, that discussed Mayer's information processing model accompanied by examples and opportunities for interaction. Each of Mayer's components, including selective attention, acquisition, construction, and integration, was discussed and examples provided.

The tutorial that addressed memory-directed strategies explained tactics to enhance memory including outlining, organizing information into graphic organizers, and linking new information with prior knowledge. Learners were directed to apply those tactics to the information they learned from the microcomputer-components tutorial by creating outlines, graphic organizers and relating new information to prior knowledge using the notes they took from the microcomputer-components tutorial. The student's name, age, responses to input questions, and generated materials were written to data files on disk. These files were available for inspection by the investigator.

The comprehension-directed tutorial elaborated on the levels of learning and generating questions according to the levels of learning. The tutorial required that students create questions at each level of learning by typing into designated fields within the tutorial. Sample questions were provided and students were permitted to access their notes from the microcomputer-component tutorial. Due to the nature of Linkway, questions that the students generated and entered into the fields were automatically saved when they exited the program so that the investigator could review results. In addition, the student's name, age, and responses to input questions were written to data files on disk.

Evaluation Instruments

Subjects completed two, delayed, and separately administered tests: one requiring cued recall and the other requiring recognition. The cued-recall test listed 50 terms which included microcomputer components,

information about memory, and computing acronyms. Students were directed to provide definitions and/or descriptions of each term. The terms were derived from the microcomputer tutorial. The recognition test included 50 multiple-choice items with 10 items at each learning level including discriminations, concrete concepts, defined concepts, rules, and problem solving. The tests were validated with the assistance of computing instructors.

Procedures

This study extended over the period of one week. On the first day of the study, students completed the microcomputer-components tutorial in 75 minutes. The microcomputer-components tutorial directed learners to take notes on the information but did not provide any specific note-taking strategies. Two days later, treatment groups completed the learning strategy tutorials in 75 minutes. On the same day, the control group continued to review the microcomputer-components tutorial without learning-strategy training for 75 minutes. One week later, students completed the recall test in 25 minutes and submitted it to the investigator. Upon completion of the cued-recall test, students completed the recognition test in 45 minutes. In addition, all data files saved to disk were reviewed by the investigator to confirm tutorial completion along with inspection of the fields where the learners typed their questions or outlines.

Results

Cued-recall Test

As seen in Table 1, the group mean scores for the cued-recall test were at or below 50% of the total points. The analysis of variance, however, indicates that the results were significant at the $p < .001$ level with an $F(2, 57) = 11.10$ due to the learning strategy training. Comparing means using the method of Least Significant Difference (LSD) indicated that the treatment group mean scores were signficantly higher than the control group mean scores. However, the comprehension-directed strategy training did not have a significantly different effect on learning as compared to the memory-directed strategy training on the cued-recall test.

Recognition Test

The group mean scores from the recognition test, found in Table 1, ranged from 33.8 to 43.8 out of a total of 50 possible items. According to an item analysis,

approximately 60% of the subjects incorrectly responded to questions related to computer memory. The ANOVA indicates that the main effects were significant at the $p < 0.001$ level with $F(2,57) = 13.31$. A comparison of means using the LSD method indicated that the group mean scores from subjects receiving comprehension-directed strategy training was significantly higher than the group mean scores from subjects receiving the memory-directed strategy training at the $p < 0.05$ level. Both treatment groups scored significantly higher than the control group on the recognition test.

Discussion

The results of this study supported the hypothesis that microcomputer-delivered comprehension-directed learning strategy training enhances learning processes assessed at the same levels of learning as the evaluation instrument. Since text-based and lecture-oriented learning strategy training has been shown to be effective (Kulik, et al., 1983), this result is not surprising but adds to an increasing body of research into the effects of microcomputer-based training (Foreman, 1990; Jensen, 1991; Laridon, 1990).

The generally low mean scores from the cued-recall test for both treatment groups and the control group suggest retrieval processes were not enhanced. This may have been due to insufficient interaction with the material for activation of memory that would otherwise result from greater depth of processing (Craik & Lockhart, 1972; Craik & Tulving, 1975). In spite of the low mean scores, however, students who received the learning-strategy training recalled significantly more terms than students who studied the microcomputer-components tutorial even though the control group interacted more with the informational materials than the treatment groups. This supports the findings of other research conclusions that teaching individuals how to learn enhances learning processes (Armbruster, 1987; Cook & Mayer, 1988; Dufflemeyer, 1987). Since students who did not receive learning-strategy training scored significantly lower than the students in the treatment groups, the study methods that they chose were less effective than those learned by the treatment groups (Wade & Trather, 1989).

The results from the recognition test indicate that student-generated questions significantly enhanced the recognition of correct answers using discrimination, conceptualization, rule application, and problem solving on a multiple-choice test. This supports previous research about the use of learner-generated questions

(Andre & Anderson, 1978-1979; Dreher & Gambrell, 1982; Duell, 1978; Levin, 1982; Simpson, 1986; Singer & Donlan, 1982; Frase & Schwartz, 1975). Since the level of knowledge for the test objectives matched the level of questions generated by students, the tactic was effective. This supports the findings of Levin (1982) and Duell (1978) who found that the role of consistency and congruency in testing is critical to the selection and implementation of learning strategies and tactics.

The effects of the memory-directed learning strategy tutorial were more significant than no strategy training and supports Weinstein's conclusions that some strategy use is more effective than non-use (Weinstein, 1982). In addition, item analysis suggests that memory-directed strategies supported learning at the lower levels of discrimination and concrete concepts. This suggests that in cases where memorization of basic vocabulary is critical, memory-directed tactics will enhance learning. Rule-using and problem solving were enhanced by comprehension-directed tactics and strategies. This supports Snowman's (1986) statement that questioning is a "comprehension-directed tactic geared more toward understanding the meaning of ideas and their inter-relationships than toward ensuring reliable recall of those ideas" (p. 256). This also explains the lack of effectiveness on retrieval processes.

Implications

The findings of this study support the use of CAI for learning-strategy training. While the learning tactics and strategies were presented separately in this study, further research into the effects of embedded strategies would contribute to an increasing body of knowledge. The consistency and congruency of test items with strategy training and specific content areas would also provide a potential area for research. Additional study about the effects of various CAI characteristics and computer-based learning-strategy training offers a tremendous potential for investigation.

Table 1. Group Mean Scores for the Cued Recall and Recognition Tests.

CUED RECALL

	Mean	Standard Deviation
Comprehension-directed Training	26.3	9.889
Memory-directed Training	25.9	10.612
Control Group	13.8	7.891

RECOGNITION

	Mean	Standard Deviation
Comprehension-directed Training	43.8	3.778
Memory-directed Training	39.4	6.021
Control Group	33.8	7.918

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